
Space Weather Technical Forecast

Issued on Thursday, 23 November 2023 at 01:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of R1 Radio Blackouts throughout. Chance of G1 Geomagnetic Storms, day 4 (26 Nov).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low activity has been observed with C-class flares, the largest a C8.9 at 22/0628UTC from AR3492. There are currently twelve sunspot groups on the visible disc, the majority of which are located in the eastern solar hemisphere. AR3492 is the largest group, located in the northeast and surrounded by several peripheral spots, each numbered individually. This spot group continues to show development across its length, especially in its trailing southern portion, with a small delta configuration evident. AR3490 to the west of AR3492 has also continued to show new growth, recently forming a delta spot in its compact southern portion. This spot is north-south magnetically aligned and interesting due to its close proximity to the larger spot in the east. AR3489 in the southeast continues to show slight decay. The sole spot in the southwest, AR3498, is spreading and showing slight decay. Finally, a new region has rotated onto the southeast limb, this spot appears large but with as yet unknown magnetic complexity. All other spot groups are simple and stable.

There are a potential of two Earth-directed CMEs observed in the past 24 hours, one from a filament eruption in the southeast and another from a dimming event but unknown origin, giving an almost full halo in current imagery. Further imagery is needed for the latter CME and computation of the former CME before they can be confidently included in the forecast.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as measured by ACE and DSCOVR at L1, have been indicative of a waning connection to CH73/+. Wind speeds have fallen from 550-600 km/s to 450-550 km/s. The solar density was generally below or around average. The IMF has steadily fallen from a maximum of 14nT down to 4nT. The important north-south component (Bz) had several periods of moderately negative/southward, peak -13nT at 22/0458 UTC, but has since eased back to weak. Phi angle was mainly positive (away from the Sun). Resultant geomagnetic activity was Active with two G1/Minor storm periods early on 22 Nov, before falling back to Unsettled by the end of the 24 hour period.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels.

GOES16 high energy (greater than 2MeV) electron flux was background to moderate levels, peaking at 241pfu at 22/2210 UTC. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu). The fluence observation at 22/0000UTC was 3.33e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily chance of M-class, and a slight chance of X-class flares, mainly from current eastern solar hemisphere sunspot regions.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs currently feature in the forecast, though a CME from a filament eruption in the southeastern quadrant early on 22nd Nov has recently been reanalysed and awaiting computation. Another CME has recently left the Sun, though we await further imagery before a full analysis can take place.

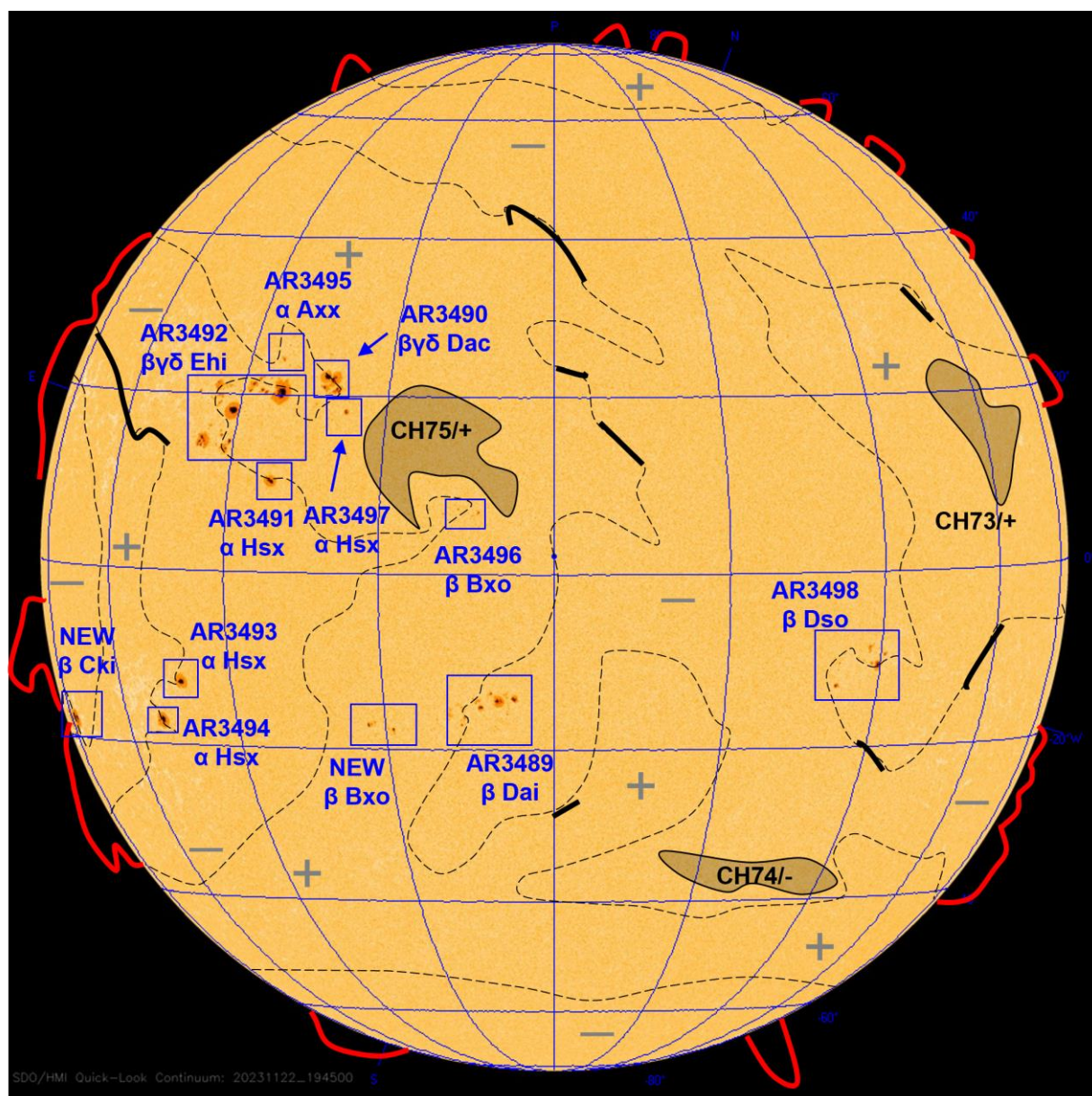
Earth remains connected to the high speed stream of coronal hole CH73/+. Elevated solar winds should ease back to slightly elevated or background levels in coming days. No further enhancements are then expected until the arrival of CH75/+ later on day 3 (25 Nov) or more likely day 4 (26 Nov), with speeds of up to 500-550 km/s possible.

Unsettled to Active initially with a slight chance of a G1/Minor Storm interval on day 1 (23 Nov). Becoming largely Quiet to Unsettled until the arrival of CH75/+ later on day 3 or on day 4 (25 or 26 Nov), bringing an increasing chance of G1/Minor Storm intervals to end the period.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels.

GOES16 high energy electron flux is expected to rise through the period with a chance of reaching high levels during the diurnal maximum. The associated 24-hour electron fluence will most likely remain below the Active ($1e8$ integrated pfu) level in this four-day period, but with a chance breaching the Active threshold between days 2-4 (24-26 Nov).

Figure 1. Solar Analysis Valid 22/2000 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

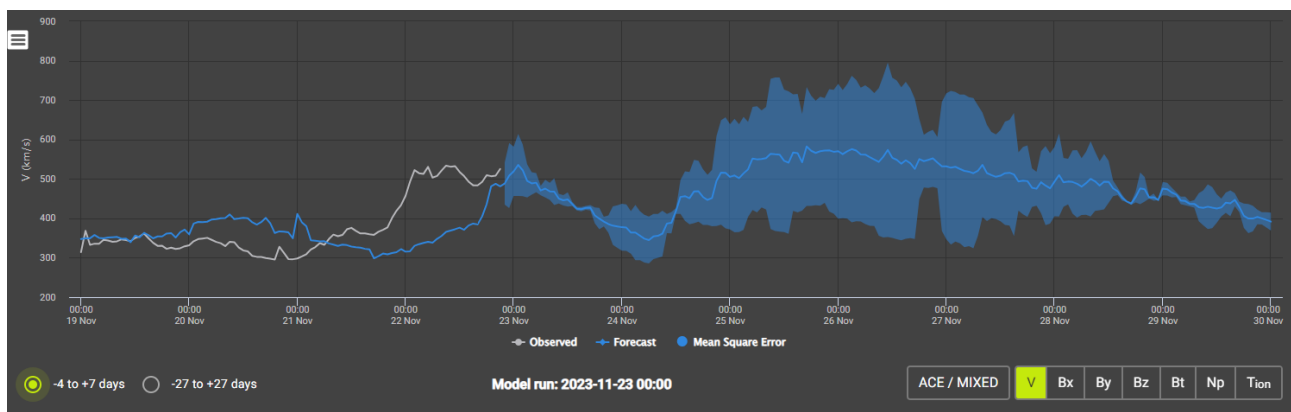
No Earth-directed CMEs currently feature in the forecast, though a CME from a filament eruption in the southeastern quadrant early on 22nd Nov has recently been reanalysed and awaiting computation in ENLIL. Another CME has recently left the Sun, perhaps a full halo, though we await further imagery before a proper analysis can take place.

Earth remains connected to the high speed stream of coronal hole CH73/+, with elevated solar winds to start day 1 (23 Nov) before gradually easing back to slightly elevated or background levels in coming days. No further enhancements are then expected until the arrival of CH75/+ later on day 3 (25 Nov) or more likely day 4 (26 Nov). On the previous rotation, this coronal hole was a much larger and darker feature than it appears currently, with speeds reaching 570 km/s and a prolonged period at elevated. Geomagnetic activity on the previous rotation was Kp 3-5. Therefore it is thought that similar if not a slightly muted version of events will take place upon the connection of the CH75/+ on this rotation. Speeds of up to 500-550 km/s are possible.

Unsettled to Active initially with a slight chance of a G1/Minor Storm interval is expected on day 1 (23 Nov). Becoming largely Quiet to Unsettled until the arrival of CH75/+ later on day 3 or on day 4 (25 or 26 Nov), bringing an increasing chance of G1/Minor Storm intervals to end the period.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	20	5	20	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC SWPM showing solar wind speed prediction. Considered a little too early with HSS arrival.



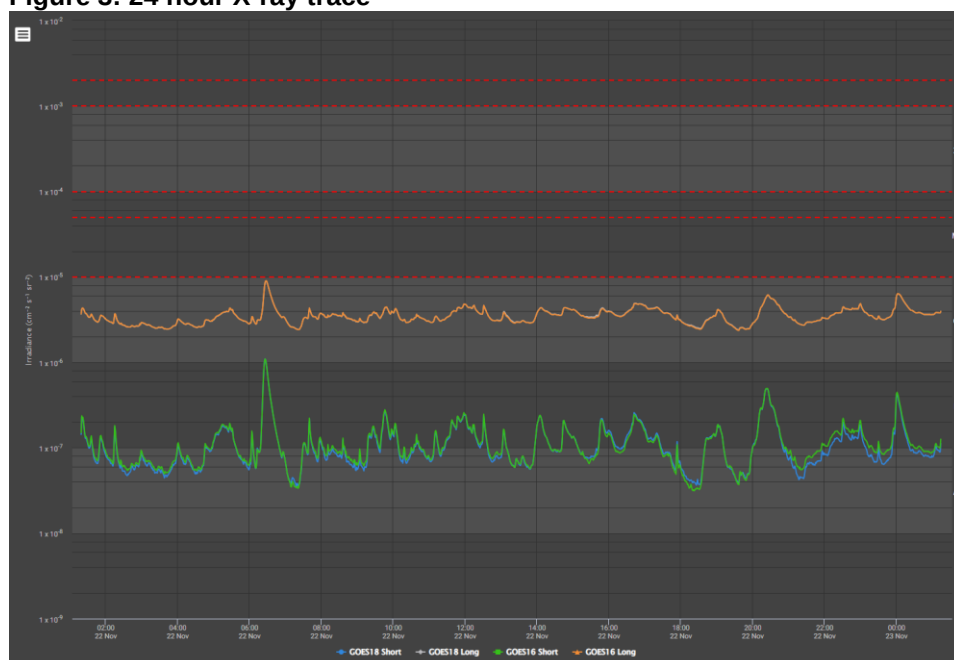
Radio Blackouts - X-Ray Flares:

There are currently twelve sunspot groups on the visible disc, the majority of which are located in the eastern solar hemisphere. AR3492 is the largest group, located in the northeast and surrounded by several peripheral spots, each numbered individually. This spot group continues to show development across its length, especially in its trailing southern portion, with a small delta configuration evident. AR3490 to the west of AR3492 has also continued to show new growth, recently forming a delta spot in its compact southern portion. This spot is north-south magnetically aligned and interesting due to its close proximity to the larger spot in the east. AR3489 in the southeast continues to show slight decay. The sole spot in the southwest, AR3498, is spreading and showing slight decay. Finally, a new region has rotated onto the southeast limb, this spot appears large but with as yet unknown magnetic complexity. All other spot groups are simple and stable.

Low solar activity is expected to continue, with a chance of M-class flares, and a slight chance of an isolated X-class flare, most likely emanating from either AR3492 or AR3490 in the northeast or the new region or AR3489 in the southeast.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: 24 hour X-ray trace



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background levels.

There are three large and complex regions on the eastern solar hemisphere, which result in an above background risk of a S1/Minor Solar Radiation Storm. This risk remains nominal until any significant groups approach the western solar hemisphere.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm ⁻² sr ⁻¹ s ⁻¹)						

High Energy Electrons Event ($\geq 2\text{MeV}$):

Electron flux levels are expected to continue fluctuating between Normal Background and Moderate flux levels initially, being suppressed by the current coronal hole high speed stream. Once the CH HSS has declined, flux levels should increase with a chance of the High 1000 pfu threshold being breached near the diurnal maximum. A further suppression is possible toward the end of the forecast period, due to the arrival of the HSS of CH75/+.

Fluence levels are expected to remain below the $1\text{e}8$ Active threshold initially, the risk of this being breached increases from day 2 as CH HSS effects wane and the electron belts recover after a period of charging.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	5	30	40	40
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM integrated flux forecast, persistence and observations.

